

What is claimed is :

1. A gas concentration measuring method using a composite gas sensor,
said composite gas sensor comprising:

5 oxygen ion conductive solid electrolytic substrates defining at least part
of a reference gas chamber and a sample gas chamber;

a sample gas introducing passage introducing a sample gas to said
sample gas chamber;

10 a pump cell having a pair of pumping electrodes for adjusting an oxygen
gas amount introduced or exhausted into or from said sample gas chamber, one
of said pumping electrodes facing said sample gas chamber and the other of
said pumping electrodes facing an outside of said composite gas sensor;

15 a first sensor cell having a pair of NOx sensing electrodes for detecting
a NOx concentration in said sample gas chamber, one of said NOx sensing
electrodes facing said sample gas chamber and the other of said NOx sensing
electrodes facing said reference gas chamber;

20 a second sensor cell having a pair of oxygen sensing electrodes for
detecting an oxygen concentration in said sample gas chamber, one of said
oxygen sensing electrodes facing said sample gas chamber and the other of said
oxygen sensing electrodes facing said reference gas chamber;

a first detecting circuit including a first ammeter and an electric power
source connected to said first sensor cell for measuring a sensing current of
said first sensor cell;

25 a pump circuit including a second ammeter and a variable electric power
source connected to said pump cell for measuring a current of said pump cell;
and

a second detecting circuit including a first voltmeter connected to said
second sensor cell for measuring a sensing voltage of said second sensor cell;

said gas concentration measuring method comprising the steps of:

30 controlling said variable electric power source of said pump circuit to
produce a constant value from said first voltmeter;

measuring the NOx concentration of said sample gas based on a measurement by said first ammeter; and

measuring an air-fuel ratio of said sample gas based on a measurement by said second ammeter.

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2. The gas concentration measuring method in accordance with claim 1, further comprising the step of measuring an oxygen concentration of said sample gas based on a measurement by a second voltmeter connected between said other pumping electrode facing the outside of said composite gas sensor and said other oxygen sensing electrode facing said reference gas chamber

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3. A composite gas sensor comprising:

oxygen ion conductive solid electrolytic substrates defining at least part of a reference gas chamber and a sample gas chamber;

a sample gas introducing passage introducing a sample gas to said sample gas chamber;

a pump cell having a pair of pumping electrodes for adjusting an oxygen gas amount introduced or exhausted into or from said sample gas chamber, one of said pumping electrodes facing said sample gas chamber and the other of said pumping electrodes facing an outside of said composite gas sensor;

a first sensor cell having a pair of NOx sensing electrodes for detecting a NOx concentration in said sample gas chamber, one of said NOx sensing electrodes facing said sample gas chamber and the other of said NOx sensing electrodes facing said reference gas chamber;

a second sensor cell having a pair of oxygen sensing electrodes for detecting an oxygen concentration in said sample gas chamber, one of said oxygen sensing electrodes facing said sample gas chamber and the other of said oxygen sensing electrodes facing said reference gas chamber;

a first detecting circuit including a first ammeter and an electric power source connected to said first sensor cell for measuring a sensing current of said first sensor cell;

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a pump circuit including a second ammeter and a variable electric power source connected to said pump cell for measuring a current of said pump cell;

a second detecting circuit including a first voltmeter connected to said second sensor cell for measuring a sensing voltage of said second sensor cell;

5 a controller responsive to said sensing voltage of said second sensor cell and adjusting said variable electric power source of said pump circuit to produce a constant value from said first voltmeter;

a NOx concentration detector associated with said first detecting circuit for measuring the NOx concentration of said sample gas based on a measurement by said first ammeter; and

10 an air-fuel ratio detector associated with said pump circuit for measuring an air-fuel ratio of said sample gas based on a measurement by said second ammeter.

15 4. The composite gas sensor in accordance with claim 3, wherein said sample gas chamber includes a first chamber and a second chamber communicating with each other via a diffusive passage,

said sample gas introducing passage is directly connected to said first chamber,

20 said one of the pumping electrodes faces said first chamber,

said one of the NOx sensing electrodes faces said second chamber, and

said one of the oxygen sensing electrodes faces said second chamber.

25 5. The composite gas sensor in accordance with claim 3, further comprising

a third detecting circuit including a second voltmeter connected between an external electrode facing the outside of said composite gas sensor and said other oxygen sensing electrode facing said reference gas chamber; and

30 an oxygen concentration detector associated with said third detecting circuit for measuring an oxygen concentration of said sample gas based on a measurement by said second voltmeter.

6. The composite gas sensor in accordance with claim 3, wherein said sample gas chamber and said reference gas chamber are provided at a same surface level.

5 7. The composite gas sensor in accordance with claim 3, wherein said other NOx sensing electrode and said other oxygen sensing electrode are a common electrode facing said reference gas chamber.

10 8. The composite gas sensor in accordance with claim 3, wherein said sample gas introducing passage is a pinhole.

15 9. A gas concentration measuring method using a composite gas sensor, said composite gas sensor comprising:
oxygen ion conductive solid electrolytic substrates defining at least part of a reference gas chamber and a sample gas chamber;

a sample gas introducing passage introducing a sample gas to said sample gas chamber;

20 a pump cell having a pair of pumping electrodes for adjusting an oxygen gas amount introduced or exhausted into or from said sample gas chamber, one of said pumping electrodes facing said sample gas chamber and the other of said pumping electrodes facing an outside of said composite gas sensor;

25 a first sensor cell having a pair of NOx sensing electrodes for detecting a NOx concentration in said sample gas chamber, one of said NOx sensing electrodes facing said sample gas chamber and the other of said NOx sensing electrodes facing said reference gas chamber;

a second sensor cell having a pair of oxygen sensing electrodes for detecting an oxygen concentration in said sample gas chamber, one of said oxygen sensing electrodes facing said sample gas chamber and the other of said oxygen sensing electrodes facing said reference gas chamber;

30 a first detecting circuit including a first ammeter and an electric power source connected to said first sensor cell for measuring a sensing current of

said first sensor cell;

a pump circuit including a second ammeter and a variable electric power source connected to said pump cell for measuring a current of said pump cell;

a second detecting circuit including a first voltmeter connected to said second sensor cell for measuring a sensing voltage of said second sensor cell; and

an impedance detector associated with said pump circuit for measuring an impedance of said pump cell;

said gas concentration measuring method comprising the steps of:

controlling said variable electric power source of said pump circuit to produce a constant value from said first voltmeter;

measuring the NO_x concentration of said sample gas based on a measurement by said first ammeter;

measuring an air-fuel ratio of said sample gas based on a measurement by said second ammeter; and

measuring a sample gas temperature based on a measurement by said impedance detector.

10. A gas concentration measuring method using a composite gas sensor, said composite gas sensor comprising:

oxygen ion conductive solid electrolytic substrates defining at least part of a reference gas chamber and a sample gas chamber;

a sample gas introducing passage introducing a sample gas to said sample gas chamber;

a pump cell having a pair of pumping electrodes for adjusting an oxygen gas amount introduced or exhausted into or from said sample gas chamber, one of said pumping electrodes facing said sample gas chamber and the other of said pumping electrodes facing an outside of said composite gas sensor;

a first sensor cell having a pair of NO_x sensing electrodes for detecting a NO_x concentration in said sample gas chamber, one of said NO_x sensing electrodes facing said sample gas chamber and the other of said NO_x sensing

electrodes facing said reference gas chamber;

a second sensor cell having a pair of oxygen sensing electrodes for detecting an oxygen concentration in said sample gas chamber, one of said oxygen sensing electrodes facing said sample gas chamber and the other of said oxygen sensing electrodes facing said reference gas chamber;

a temperature detecting cell having a porous substrate provided on said pump cell and a resistor provided on an outer surface of said porous substrate;

a first detecting circuit including a first ammeter and an electric power source connected to said first sensor cell for measuring a sensing current of said first sensor cell;

a pump circuit including a second ammeter and a variable electric power source connected to said pump cell for measuring a current of said pump cell; and

a second detecting circuit including a first voltmeter connected to said second sensor cell for measuring a sensing voltage of said second sensor cell; said gas concentration measuring method comprising the steps of:

controlling said variable electric power source of said pump circuit to produce a constant value from said first voltmeter;

measuring the NO_x concentration of said sample gas based on a measurement by said first ammeter;

measuring an air-fuel ratio of said sample gas based on a measurement by said second ammeter; and

measuring a sample gas temperature based on a measured resistance value of said resistor in said temperature detecting cell.

11. The composite gas sensor in accordance with claim 3, wherein said sample gas introduction passage is formed by a porous layer having a porosity larger than that of said solid electrolytic substrates.

12. The composite gas sensor in accordance with claim 3, wherein said pump circuit is associated with an impedance detector that detects an

impedance of said pump cell to measure a sample gas temperature.

13. The composite gas sensor in accordance with claim 3, further comprising a temperature detecting cell having a porous substrate provided on said pump cell and a resistor provided on an outer surface of said porous substrate for measuring a sample gas temperature based on a resistance value of said resistor.

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